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*THE WORK OF THE COAST AND GEODETIC SURVEY.**

IT is a high privilege to address you today on the work of the oldest bureau of applied science under the government, a bureau which invokes the aid of science in its intensely practical work, where theory and practice go hand in hand. It seems reasonable to hope that some inspiration may be drawn from an account of its work, by young men who are about to take up the pleasures and burdens of a share in the world's work after going forth from an educational institution which announces as the underlying principle which controls its method, the advance of the practical, side by side with the scientific. It is particularly pleasant to speak of the survey in a locality where such familiar names as Lovering, Bowditch and Pierce will be recognized as among those who helped it in its earlier struggles for recognition, and that of a statesman like Charles Sumner as one of its staunch supporters, those of Louis and Alexander Agassiz, who utilized the opportunities afforded by the survey to further the aims of science and to add luster to the fame of its work by their association with it, and where it will be remembered that if Massachusetts gave a Peirce to the survey, the survey gave a Mendenhall and a Pritchett to Massachusetts.

* Commencement address delivered before the Worcester Polytechnic Institute.

THE SURVEY'S PLACE UNDER THE GOVERNMENT.

On the first day of next month the Coast and Geodetic Survey will be transferred from the Treasury Department, of which it has been a bureau since 1836, to the newly created Department of Commerce and Labor. This is in accordance with the logic of events. As long as the fiscal department of the government was charged with matters pertaining to commerce the survey found a proper place there, but when the new department was created with functions especially designed to care for the interests of commerce, the survey, being primarily devoted to the interests of commerce, necessarily became a part of it.

The Coast and Geodetic Survey is charged with the survey of the coasts of the United States, including Alaska, and all coasts under the jurisdiction of the United States; the survey of rivers to the head of tide-water ship navigation; deep-sea soundings; temperature and current observations throughout the Gulf Stream and Japan Stream flowing off these coasts; tidal observations, magnetic observations and gravity research; determinations of heights by geodetic leveling, and of geographical positions by lines of transcontinental triangulation which, with other connecting triangulations and observations for latitude, longitude and azimuth, furnish points of reference for state surveys and connect the work on the Atlantic with that on the Pacific coast.

The results of the survey are published in the form of annual reports, which include professional papers of value; bulletins, which give information deemed important for immediate publication; notices to mariners showing changes on charts and reported dangers affecting them; tide tables issued annually in advance; charts upon various scales, including harbor charts, general charts of the coasts and sailing charts, chart catalogues and coast pilots.

ITS GEOGRAPHICAL DOMAIN.

Such in general are its present duties, but when the survey was first planned the coasts under contemplation extended only from the eastern boundary of Maine to the northern boundary of Florida, and on the Gulf coast the shores of the Louisiana Purchase marked the limits of the survey's authority; later on its duties were extended to keep pace with the expansion of the country to the Floridas and the whole of our present Gulf coast, to Oregon and California, to Alaska, and still more recently to the Hawaiian Islands, to Porto Rico and to the Philippines. With the acquisition of Oregon and California and the prosecution of surveys of their coasts arose the necessity for a trigonometric connection between the work on the Atlantic and Pacific coasts, and Congress authorized the extension of the triangulation inland for that purpose, and for the purpose of aiding topographic and state surveys.

The acquisition of the vast territory of Alaska added greatly to the duties of the survey. Beginning at the historical parallel of fifty-four forty, which the popular cry of 'fifty-four forty or fight' demanded as the northern limit of our Pacific coast possessions, the coast of Alaska stretches northward, including the great archipelago which ends at Cape Spencer. Northward of that is Yakutat Bay and Prince William Sound. The latter is assuming commercial importance and is, therefore, now the locality in which the survey is especially active. Farther north is Cook's Inlet, a great bay where the phenomenal rise of the tide, which yet remains to be investigated, rivals or exceeds that of the Bay of Fundy.

North of the Alaskan peninsula the Kuskowim River empties into the Bering

Sea. This large river has its head waters at the base of Mt. McKinley, the highest mountain on our continent, and among Alaskan rivers is second only to the mighty Yukon, whose desolate delta the survey has already charted. No matter how inhospitable the shores, how rugged and forbidding, they will not challenge in vain the skill and daring of our surveyors, as was foretold by Charles Sumner in his speech in favor of the acquisition of Alaska, in which he alluded to the Coast Survey as follows: "An object of immediate practical interest will be the survey of the extended and indented coast by our officers, bringing it all within the domain of science, and assuring to navigation much needed assistance, while the republic is honored by a continuation of national charts, where execution vies with science and the art of engraving is the beautiful handmaid."

The Aleutian Islands, with their towering volcanoes and rugged and bold coasts, stretch westward for twelve hundred miles from the Alaskan peninsula and need yet to be accurately charted. This chain of islands lies along the shortest route from Puget Sound to the Philippines, a route which has already been followed by a ship of the survey in transferring its activities from the sub-arctic waters of Bering Sea to the tropical waters of the Philippines.

In this new domain the survey has another extensive field of operations. For in general the surveys which were made prior to the coming of the Americans are lacking in accuracy and reliability, and are not at all suited to meet the wants of an active commerce. The Philippine archipelago stretches northward from about latitude 5° to 21° and through about ten degrees of longitude, and the intricate shore line of its islands surpasses in length that of the United States proper. Our Samoan island possessions and Guam remain to be surveyed, but in the Hawaiian Islands the most needful work has been accomplished. The size of the Philippines will be better understood by comparison with an island with which we are reasonably familiar. Five islands in the Philippines are as large or larger than Porto Rico, and two of these each about ten times as large.

To Porto Rico the survey promptly extended its work, for, almost before the smoke of battle had cleared away, Admiral Sampson called for accurate surveys of the coasts of Porto Rico in a telegram addressed to the Secretary of the Navy, who requested the survey to begin the charting of its coasts. The work was at once inaugurated, with surprising results. Harbors which had been unknown to the cartographer were discovered, surveyed and mapped. A triangulation was extended around the island and as far eastward as the Danish island of St. Thomas, across the Virgin Passage, famous as the principal entrance into the Caribbean Sea, and near which lies the winter rendezvous of our navy. All the principal harbors have been charted and the results given to the world. One of the interesting results of these surveys is that cartographically the northern shore of the island was moved southward half a mile and the southern shore northward by the same amount. The cause of this is that the visible island of Porto Rico is really the summit of a mountain whose slopes extend to great depths below the adjacent seas. The results of observations for latitude made on the north and south sides of this summit are affected by local attractions of mountain masses which cause deflections of the plumb line and which must be taken into account in charting the island.

ITS GEODETIC FUNCTION.

When the inauguration of the survey was under discussion at the beginning of the

century it was held an open question by some whether the work should be coordinated by purely astronomical observations or whether it should be based on a trigonometric survey, and happily the latter method was chosen and prescribed.

From carefully measured bases chains of triangles were to be extended along the coasts. Their direction and geographical location were to be determined by astronomical observations. The skeleton of triangles was to be clothed by the topographer, who should delineate the topographic features as far as might be necessary for commerce and defense. By making proper use of the trigonometric and topographic features thus determined the hydrographer would follow and sound the depths of the waters, develop the channels fit for safe navigation, discover all hidden dangers, measure the tides and the currents, and thus furnish what was needful for a safe chart. As a matter of fact, this sequence of work, though it is of necessity observed in local surveys, was never followed when the Coast Survey as a whole is considered. The rapid commercial development of this country made it necessary to meet particular demands in some localities at once, leaving others of lesser urgency to be dealt with later on, but the general scheme of proper coordination by a principal triangulation was never lost sight of, though the latter oftentimes followed long after the local surveys had been made. This experience is being repeated in Alaska and particularly in the Philippine Islands, where the survey is constrained by the needs of commerce to make surveys here and there, wherever routes of travel or anchorages have to be developed, leaving it to the future progress of the survey to coordinate all this work.

The distances of the stars, the sun and the moon from the earth as we know them have all been measured, to use the language of a former astronomer royal of England, by means of a yard-stick. For the purpose of this illustration it is immaterial that the particular yard-stick of this survey is the meter. The point is that with a short bar we measure a relatively long base, from this we extend a triangulation over relatively much longer distances, from these distances we deduce the size of the earth and its diameters and thus have found the basis of all dimensional astronomy. The triangulation of the Coast and Geodetic Survey, therefore, subserved not only its immediate purpose of serving as a basis for accurate charting of the coasts, but contributed by its great extension to a knowledge of the earth's dimensions and figure, a problem which has occupied the mind of man since Eratosthenes, 300 B.C., to the present time. For the survey has completed a triangulation from Eastport, Maine, to New Orleans, Louisiana, a distance of 2,400 kilometers, and another from Cape May to San Francisco along the 39th parallel, a distance of over 4,000 kilometers. It is just now engaged in extending another great chain of triangles, which has been measured between the southern boundary of California and a point beyond San Francisco, towards Puget Sound, where in turn it will be connected with our northern boundary. Along the 98th meridian also a chain of triangles is being measured, and it is hoped that the Republic of Mexico on the south and Canada on the north will prolong its measurement through their respective domains. Branching from this meridian a line will cross to the eastward to connect with the admirable triangulation of the Lake Survey which has already been connected with the primary triangulation of the Coast and Geodetic Survey in other places.

The great triangulation already com-

pleted has been adopted as a standard of reference for all future trigonometric work of the survey in so far as purely geographic and topographic purposes are concerned and this great country will soon have a homogeneous system of geographical coordinates which will serve, it may be confidently believed, for all times to come, the manifold uses to which it can be put by the national government, by the states and municipalities and by engineers and surveyors.

Intimately connected with the question of the dimension of the earth is that of its figure, and here the pendulum will play an important part. The earlier work of the survey with the pendulum has its chief value in showing the limitations of the methods and appliances used. Much simpler and more reliable apparatus was introduced some years ago and has given satisfactory results. The apparatus was used not only in relative gravity observations in this country but for the purpose of connecting our own base station with the English and continental ones, a work which was rendered possible by a subvention from the International Geodetic Association. At the present time no gravity work is being done, it being deemed advisable to study the deflections of the plumb line as brought out by a reduction of the triangulation to a common system. When that has been done the pendulum may perhaps serve to indicate relations between any anomalies that may develop in particular localities and the force of gravity in the same regions.

Closely related to these geodetic features of the work of the Coast Survey are the astronomical determinations and especially the determinations of telegraphic longitudes. Long ago the survey determined the difference of longitude between Europe and this country by means of the Atlantic cable. It has covered this country with a well-adjusted network of stations and is now stretching its determinations westward across the Pacific. The longitude between San Francisco and Honolulu is being determined while we are gathered in this hall, and the observers are getting ready to meet the new cable at Guam within a few weeks in order to extend the work to Manila. Manila has been the base station for our observers in the Philippines, who have been for two years busily engaged in utilizing the local cables and land telegraph lines for similar purposes. The geographic explorations in Alaska, the boundary question and the surveys in that territory call for further and immediate extension of this work there. But it requires no great stretch of the imagination to believe that the wireless method of sending signals will at no distant day make us independent of cable or telegraph lines as far as longitude work is concerned, and for this purpose the method would be an ideal one. Last summer, as an experiment and with short-distance instruments, a chronometer on one of the survey vessels transmitted automatically its half-second beats to a shore station over sixty miles away, where they were received and automatically recorded on a moving tape.

In the leveling of precision we have still another class of work belonging to the geodetic function of the survey. Here the aim of the survey is to furnish a series of primary bench marks properly related to the mean sea level of the Atlantic, Gulf and Pacific coasts which shall serve to correlate the thousands of miles of levels which have been and are being run by the railways, the canal enterprises, the Geological Survey and the engineers of the United States Army for many different purposes, but all for the common good. It is pleasant to record that through the cooperation

of the other government surveys concerned, their results are all being placed at the disposal of this bureau for the purpose of including them in a general adjustment by which a homogeneous system of vertical coordinates for the whole country can be established which shall stand side by side with geographical coordinates before referred to.

THE DATA FOR A CHART.

The geodetic functions of the survey have been dwelt upon in this address at some length because their precise nature and great usefulness are not commonly understood, but the administration of the survey has always remembered that the survey owes its existence to the urgent need for reliable charts of the coasts. Their importance to commerce is apparent. The vast sums which every civilized nation is expending in improving its facilities for commercial intercourse are sufficient evidence that everything which can be done to promote the safety of navigation must be done. Every civilized nation also recognizes the fact that this is a duty which it owes not only to its own citizens, but to the world. As an evidence of this consider the lighthouses which flash their friendly warnings or guiding welcome to ships in all parts of the world, the buoys which mark dangers along channels, the sounding sirens which cry their caution through the fogs, the storm signals which are displayed, the sturdy life-savers who patrol the coasts and the guiding charts with which this survey is mainly concerned.

On the open ocean the chart has its least value, for the dangers to which the mariner is there exposed are not such as can be remedied by a chart. Storms, fogs and collision with other ships in the lanes of travel are dangers to be apprehended, but the knowledge that there is deep water under the keel of the ship is a source of comfort to the mariner, however risky it may appear to the landsman. The story of the darky who compared the dangers of a sea voyage with the safety of railway travel is familiar to all: "If the ship sinks whar is yo, but if the train gits smashed dar yo is," illustrates one point of view, but that of the sailor is told in rhyme which the refined muse of the Worcester Polytechnic may not know and is therefore cited here:

Foolhardy chaps as lives in towns,
What danger they are all in,
And now lie quaking in their beds
For fear the roof should fall in.

Poor creatures, how they envies us,
And wishes, I've a notion,
For our good luck, on such a night
To be upon the ocean.

* * * * * * *

While you and I, Bill, on the deck
Are comfortably lying,
My eyes! what tiles and chimney-pots
About their heads are flying.

But when the ship nears the coast a burden of great responsibility rests upon the navigator, for on his skill, experience and knowledge the safety of life and property entrusted to his care depends. He turns to the chart and follows the path marked out for him by the skill of the surveyor. When the depth of water is great as compared with the draft of vessels, the problem of the hydrographer is comparatively simple, but where it decreases so as to exceed not very much the draft of vessels, the problem of finding every hidden rock, every coral pinnacle or shoal, requires an immense amount of work and minute accuracy in the soundings and locations. Imagine to yourselves a totally submerged city and solve the problem of finding every chimney, every steeple, every house top and every street by means of a sounding lead, and you will have a good illustration, even though it be a slightly exaggerated one,

of the difficulty of making an accurate hydrographic survey in regions where the coral rocks rise in pinnacles from relatively great depths with appalling suddenness. As a concrete example take a small area about 400 square miles lying between Porto Rico and St. Thomas, a region used by our fleet for its maneuvers, and consider what it means to find with the lead every hidden coral rock or reef which might cause the destruction of a seven-million-dollar battleship.

Not only must the depths be correctly shown, but as a further aid to navigation the characteristics of the bottom must be indicated, and there are places on the Atlantic coast where the nature of the bottom, as disclosed by the material which is brought up by the sounding-lead, is so characteristic of the particular locality that it tells the navigator the exact position of his ship.

When the triangulation and topography are complete, and the channels and general configuration of the bottom have been developed and charted in their true relation to the natural or artificial objects on shore which guide the navigator, yet is the chart not complete. The rise and fall of the tide as affecting the indications of the chart must be known at any time in present and future. To the difficult problem of the tides the survey has also addressed itself, and permanent stations are maintained which record automatically the stages of the tide. The information furnished by them is supplemented by shorter series of observations made at intermediate places by our own surveying parties or by others. The commerce of this country, however, knows no geographical boundaries, and the survey collects and publishes annually in advance a volume giving predictions for nearly all the ports of the world.

Another branch of the survey which covers a broad field of observation and research is that of terrestrial magnetism, represented on the chart by compass diagrams. In order to draw them correctly and by means of them to show the amount of the variation of the needle at given localities, the magnetic elements have been investigated from the earliest days of the survey. At first these investigations were inaugurated in the interests of the mariner alone, and confined to the neighborhood of the coasts, but as years passed the demands made on the survey for more information required their extension to the whole area of the United States and beyond. The intimate relation of the compass to property surveys is the chief case in point. The rerunning of the boundaries of old estates, the interpretation of old deeds in litigation, require a knowledge of the amount of the needle's variation in the present time and the means of computing its direction in the past. In the more delicate work of the electrical engineer the earth's magnetic elements have also to be taken into consideration. Side by side with the practical requirements the scientific phase of the subject has been kept in view, with full faith in the belief, which is based on the history of science, that the things which to-day are speculative and abstruse will to-morrow belong to the commonplace applications of science to the daily wants of the community. The survey now maintains a small magnetic observatory in Porto Rico; a complete and modern one at Cheltenham, Maryland; another at Baldwin, Kansas; one at Sitka, Alaska; and yet another near Honolulu in the Hawaiian Islands. We may hope, therefore, that the United States will contribute no small share towards finding the mysterious cause of the earth's magnetism, or at least in furnishing the data necessary for a more

perfect understanding of the laws which govern its manifestations.

How the information gathered by the various branches of the field work is utilized in the office and prepared for publication belongs to another chapter which can not be read to-day. Nor will time permit a reference to the mechanism of its organization. What the survey is and does is due to the men who composed its working force in the past and who compose it in the present, and, therefore, this fragmentary account may be fitly closed with a brief reference to the men who carry out its field work.

While there is a proper amount of specialization which leads to excellence in particular branches of work, the field officers hold themselves in readiness to perform any kind of duty which may be required of them. It may be to pack a mule train or to command a ship, to pitch a camp or outfit a vessel, to sound along the edge of resistless breakers, to climb glaciers or to break through tropical jungles, to guide vessels through uncharted dangers or men along a mountain trail, to look after the health of their men in all climates, to provide months in advance for supplying them with food in regions where none can be purchased, to build structures which shall tower over tall trees of the western forests in order to see distant stations, to observe the stars by night, to watch the swinging pendulum for the determination of gravity, to measure the forces of the earth's magnetism, to note the tides and currents, to sound the waters of the ocean, to map the topography of the land, to trace international or state boundaries, to cover the land with a network of triangulation, or to join their no less zealous co-workers in the office in the reduction and discussion of results. Long as this recital of their occupation may seem, it is but a tithe of what might be said. Surely the merest contemplation of these duties shows how high the calling of the men who must perform them, and if high thinking and plain living and a life of deeds are things which deserve admiration, they earn it day and night, year in and year out.

Perhaps the zeal and devotion to duty is born in part of the difficulties which men must overcome in the accomplishment of a great purpose. But to whatever it is due, it appears to be common to the craft, as appears from the tribute paid to the British surveyors by the historian of the Great Trigonometrical Survey of India, a tribute which is cited here for the glory of the engineering profession.

"It is and has been a very noble band, that body of surveyors who have been trained and have worked under Lambton, Everest, Waugh and Walker. It is no small honor to be at their head. These men must combine the knowledge and habits of thought of a Cambridge wrangler with the energy, resource and presence of mind of an explorer or backwoodsman, and they must add to this the gallantry and devotion which inspire the leaders of a forlorn hope. The danger of service in the jungles and swamps of India, with the attendant anxiety and incessant work, is greater than that encountered on a battle-field; the percentage of deaths is larger, while the sort of courage that is required is of a far higher order. The story of the Great Trigonometric Survey when fitly told will form one of the proudest pages in the history of English domination in the East."

Is there anything which can stir the blood more than this reference to the fierce conquest of great difficulties in order to achieve a high purpose, or anything more ennobling than the contemplation of unselfish devotion to duty?

O. H. Tittmann.

U. S. Coast and Geodetic Survey.

*RECENT DEVELOPMENTS IN THE STUDY OF RADIOACTIVE SUBSTANCES.**

BARELY eight years have elapsed since the discovery of Becquerel rays. Yet during that time the subject of radioactivity has developed so rapidly that it has now become an important branch of physics and chemistry. The phenomena are interesting in themselves, in some cases almost startling. But even more important is the bearing of the results upon some of the conceptions that lie at the very foundation of physical science. The study of radioactivity seems destined to exert a profound influence upon physical and chemical theories.

Without entering into the history of the subject, I shall first call attention to the results that are now best established, putting the facts into as systematic form as possible. The contradictory character of the early work, and the great complexity of the phenomena themselves, make this as difficult as it is desirable.

A radioactive substance may be defined as a substance which sends out Becquerel rays; *i. e.*, rays that are capable of penetrating bodies usually regarded as opaque, and which produce certain characteristic photographic and electric effects. In their general behavior such rays show a close resemblance to Roentgen rays; the differences will be referred to later. In the table below is given a list of the radioactive substances now known.

RADIOACTIVE SUBSTANCES.

Permanently Active.

Uranium ....(238)
Thorium ....(232)
Radium ....(225†)
Polonium.........(radioactive bismuth)
Actinium.
Radioactive lead.

Temporarily Active.

Ur-X, Th-X, excited activity obtained from air, from freshly fallen rain or snow, or from permanently active bodies.

It will be noticed that the list is divided into three groups. The first, containing uranium, thorium and radium, consists of elements whose separate existence is well established. This statement may now be made in the case of radium as well as in the case of the other two, since this substance has recently been so completely isolated as to make possible the determination of its atomic weight, while it has been shown by several observers to possess a characteristic spectrum. It will be noticed that the elements in this radioactive group possess atomic weights greater than any other known elements.

The second group is made up of suspected new elements. These elements have not been isolated and have not yet been found to give characteristic spectra. It is thought by some that the radioactivity in these cases is due to the presence of a trace of radium—so small as not to be detected by an ordinary test. It appears to me that the arguments against this view are strong. But the question can only be settled by more extended experimental study.

In the case of the substances of the first two groups, with the possible exception of polonium, the radioactivity is permanent so far as our present knowledge goes. In other words, these substances continue to give out Becquerel rays without special stimulation, such as is required for ordinary phosphorescence, and with no diminution in intensity that has thus far been detected. The question as to whether any

* Address delivered before the Cornell Section of the American Chemical Society on May 18, 1903.

† A study of the spectrum of radium has led Runge and Precht to assign to this new element the atomic weight 25.8 instead of the value 22.5 obtained by Madame Curie by chemical methods. Some uncertainty therefore still exists.

substances are permanently active in a strict sense is not to be regarded as settled. I think, however, that most physicists feel that all active substances must gradually lose their activity, even though the rate of loss is too small to have been yet detected.

A third group of substances contains those which possess temporary activity, lasting for a period ranging from a few minutes to several months. Temporary activity may be acquired in a large number of ways. It may be obtained from the atmosphere, from freshly fallen rain or snow, from certain products developed by chemical processes from other active substances, and in a variety of other ways.

In dealing with the effects of the rays produced by radioactive substances we may conveniently adopt the classification shown in the list given below.

EFFECTS OF BECQUEREL RAYS.

Photographic action.

Electric effects. (The most important of these is the power possessed by the rays of making air and other gases temporarily conducting.)

Luminous effects. (Fluorescence produced by the rays in various substances.)

Chemical effects. (Development of ozone, color changes produced in glass, etc.)

Physiological effects. (Burns produced by long exposure to the rays; sensation of light produced by highly active preparations held near the eye.)

Like Roentgen rays, the rays sent out by radioactive substances do not show regular reflection or refraction.

It will be noticed that practically all of the effects produced by Becquerel rays are also produced by X-rays. It would be natural to conclude that the rays are of the same type. Yet there are enough differences in the properties of the two rays to show that this can not be true. For example, Becquerel rays are deflected by a magnetic field and by an electric field and carry an electric charge. X-rays possess none of these properties. It is probable that a radioactive substance sends out *some* X-rays; but the bulk of the rays emitted by it are of a different kind.

The methods used in studying Becquerel rays are naturally based upon the various effects which these rays produce. Up to the present time the photographic effect and the electrical effect have been the ones chiefly employed in the study of the rays. Of the two the electrical method is capable of far greater sensitiveness. In brief, this method is applied in the following way: An insulated conductor of small capacity is connected with a sensitive electrometer and is then charged to a potential of one to two hundred volts. This conductor is placed in a metallic vessel whose walls are grounded. With good insulation the conductor will hold its charge under ordinary circumstances for a long period; but if Becquerel rays are allowed to enter the vessel they make the air a conductor and thus permit the charge to escape. The rate at which the charge escapes, as indicated by the electrometer, is a measure of the intensity of the rays.

In the early study of the subject different observers often obtained contradictory results. In many cases the contradictions have since been explained by the fact that some used the photographic method while others used the electrical method. The two methods of measuring the intensity of the rays do not agree. For example, a substance *A* may produce very strong photographic effects, while another substance *B*, also tested photographically, is found to give out rays that are relatively weak. But if the two substances are compared by means of the electrical effects which they produce, it may turn out that *B* is more active than *A*.

Results such as this have led to the conclusion that there are different kinds of

Becquerel rays, some of which produce strong photographic effects, while others, not so strong photographically, produce intense electrical effects. More recently it has been found not only that the rays from different substances differ, but that a single substance sends out rays of widely different properties. Three types of Becquerel rays have thus far been recognized. An active substance in general sends out all three kinds, but the distribution of the radiation among the different types depends on the substance. For convenience these rays have been referred to as the α, β and γ rays. A brief statement of more important properties of each kind of ray is given in the accompanying table.

DIFFERENT TYPES OF RAYS.

α Rays.

Readily absorbed (*e. g.*, by a thin sheet of aluminium foil, or even by a few centimeters of air).

Relatively strong electrically, *i. e.*, in making gases conducting.

Photographic effect small.

Behavior in an electric field and in magnetic field such as to indicate that these rays are positively charged particles of molecular dimensions moving at a speed of about 10^9 cm./sec.

β Rays.

Quite penetrating (*e. g.*, pass through several millimeters of aluminium or glass).

Electrical effects weak.

Photographic effects relatively strong.

Carry a negative charge.

Probably consist of negatively charged particles, much smaller than atoms, moving at a speed nearly equal to the speed of light, *i. e.*, 3.10^{10} cm./sec. Behavior in electric and magnetic field consistent with this view.

γ Rays.

Highly penetrating. Pass through several centimeters of metal.

Probably Roentgen rays.

The existence of these different kinds of rays may be proved and their separation may be effected in a number of different ways. The most obvious way is by means of absorption. For example, a layer of aluminium foil will absorb practically all of the α rays, while it permits the β rays to pass with scarcely any diminution in intensity. To separate the β rays from the γ rays by absorption is more difficult, for both of these rays are highly penetrating. Separation may here be effected, however, by passing the rays through a magnetic field, since the β rays are deflected, while the γ rays are not.

Let us consider first the β rays. Practically all physicists now agree in regarding these rays as consisting of very small negatively charged particles, or electrons, moving at great speed. That they carry a negative charge has been shown by direct experiment. It is also an experimental fact that these rays are deviated in a magnetic field, and in an electric field in the manner that would be expected if they were charged particles in motion. But the quantitative relations are such as to indicate that if this hypothesis is correct the mass of each particle must be much less than the mass of the smallest atom, while the speed of the particles must be nearly the speed of light. Each of these statements seems so incredible and revolutionary that it is difficult to accept the hypothesis, even in spite of its complete agreement with experiment at every point where a test can be applied. I think that the difficulty in accepting this hypothesis is probably greater in the minds of chemists than it is with physicists. The battle over the electron theory in its purely physical aspects had already been fought out during the development of the theory of kathode rays.* The behavior of the β rays is so similar to that of kathode rays,

* The development of this subject has been traced by the writer in an article on 'Kathode Rays and some Related Phenomena,' SCIENCE, Vol. XII., p. 41, 1900.

that the electron theory, which has now been universally accepted in the case of the kathode rays, has naturally been extended to include the Becquerel rays.

Until recently the α rays were supposed to be undeflected in passing through a magnetic field. Within the last few months, however, it has been shown both by Rutherford and Becquerel that these rays do experience a deflection. This deflection is in the opposite direction from that experienced by the β rays, and is much less in amount. An extremely strong field is necessary to show the deflection at all. This behavior of α rays is explained by assuming the rays to consist of positively charged particles moving at high speeds. It appears, however, that the particles are much larger, that the speed of these rays, instead of being nearly that of light, is only about one tenth as great.

The third type of rays, the γ rays, has been only slightly studied; but so far as investigation has proceeded the properties of the γ rays are the same as those of X-rays. These rays are highly penetrating and have been found to pass through several centimeters of metal.

The intensity of the rays from radium is much greater than that of the rays from the other active substances. Nearly pure radium preparations have been made which show an activity, as measured by the electrical effect, five hundred thousand times as great as the activity of metallic uranium. Small traces of radium in minerals thus add greatly to the activity of these minerals, even when the amount present is so small that no chemical test can detect it. The electrical and photographic methods of testing for radioactivity are, in fact, more sensitive than any chemical or spectroscopic tests yet discovered.

The great difference between the activity of radium and that of the other active substances, and the fact that small traces of radium are hard to detect, has led to the thought that the activity of other substances might be due to the presence as an impurity of some highly active element, possibly radium itself. In the case of uranium it seemed for a time as though this view was definitely confirmed. Upon precipitating a solution of uranium by ammonium carbonate Crookes succeeded in separating uranium into two parts, one of which was redissolved by excess of the reagent, while the other remained behind as a precipitate. Only a trace of the latter was obtained, but it was many times more active than the original uranium. In fact, when tested by photographic methods this uranium-X, as it is called, seemed to have *all* of the original activity, while the ordinary uranium was no longer active. It was found, however, that the uranium-X soon lost its activity, falling to one half its original strength in about twenty-two days; while the ordinary uranium gradually recovered its activity, regaining one half of its original strength in about the same length of time.

The investigation which led to the separation of uranium-X illustrates the contradictions which may arise in work of this kind. Crookes used the photographic method and obtained the results just stated. Others, repeating his work by the electrical method, reached very different conclusions. When tested electrically the increased activity of Ur-X was not nearly so marked, while the ordinary uranium was nearly as active as ever. The separation is now seen to be one which divides the active uranium into two parts, both of which are active; but one part gives out α rays, while the other gives chiefly β rays. A similar separation has been effected in the case of thorium. In this case thorium nitrate is precipitated

from solution by ammonium hydrate. The filtrate, which is free from thorium, when evaporated to dryness shows an activity measured electrically fully one thousand times as great as that of the original thorium. Thorium-X, like Ur-X, is present as a trace only. Its radiation consists chiefly of β rays. But both thorium and Th-X develop rays of both kinds.

It was early found that both thorium and radium possess the power of exciting temporary activity in bodies placed near them. This excited activity may also be produced by bringing air that has been in contact with radium or thorium past the body to be excited. The results are explained by the fact that thorium and radium each give out an 'emanation,' which behaves in all respects like an inert gas. This emanation is itself radioactive, as may be shown by the electrical effects produced by it, and it also has the power of exciting temporary activity in bodies with which it comes in contact. The emanations lose their activity rather rapidly; in the case of thorium the activity falls to one half its original value in about one minute, while in the case of radium a similar loss occurs in the course of several days. Radium and thorium are the only substances that give emanations; they are also the only substances which have the power of exciting activity in neighboring bodies.

That the emanations of radium and thorium are gases is confirmed in a great variety of ways. For example, they can be occluded by porous solids, such as the solid salts which develop them. Owing to the fact that the radium emanation preserves its activity for a long time, the occlusion of this emanation is more readily studied. A large part of emanation developed by radium is occluded by the radium salt itself; this may be driven off by heating, after which considerable time is required for the original condition to be restored. When the active salts of radium or thorium are in solution the emanations developed are liberated more rapidly, there being in this case no chance for occlusion. The rate at which the emanation is developed appears to be constant under all conditions.

The emanations of both radium and thorium are chemically inert. They may be passed through sulphuric acid, nitric acid and hydrochloric acid without change, and are also unaffected by passing over red-hot lead chromate or magnesium. They may be condensed, however, by passing through a tube immersed in liquid air. The radium emanation condenses at —150° C., and that of thorium at about —120° C. The rate of decay of the emanation is unaffected by this low temperature. When the temperature is raised again the emanations are liberated with an activity depending only upon the time that has elapsed since they were developed.

The excited activity produced by the emanations of radium and thorium is greatest on bodies that are negatively charged. It would seem, therefore, that the substance to which excited activity is due must itself be positively charged. If the substance is sending out more β rays than α rays such a positive charge would naturally follow.

Temporary activity may be acquired by exposing a negatively charged body to ordinary air. Apparently the atmosphere contains a radioactive gas similar to the emanations mentioned above. This view is strengthened by the fact that freshly fallen rain and snow possess temporary activity, probably obtained from the air. Air from cellars and air that has been drawn from a porous soil are especially rich in this active constituent. J. J.

Thomson has recently found that the water from certain deep wells in Cambridge also contains a radioactive gas.

Several general points brought out in recent years should not be lost sight of, since their bearing upon the theory of the subject seems to be important.

Radioactivity seems to be unaffected by temperature. Neither the activity of a substance nor the rate of decay in the case of temporary activity is affected by a change of temperature as great as that from liquid air to a white heat. None of the physical agencies which usually affect physical phenomena seems to influence radioactivity. These facts, together with the fact that the salts of the active elements are active as well as the elements themselves, have suggested the thought that the phenomena of radioactivity are phenomena of the atom rather than of the molecule.

There are many indications that radioactivity is accompanied by some change in the active substances. For example, the Th-X may be removed from thorium completely; but at the end of a month or so the thorium may be again treated in the same way and as much Th-X obtained as before. It seems as though the development of Th-X was proceeding slowly all the time. The Th-X must itself be undergoing some change, since its activity diminishes steadily from the time of its separation. Further evidences of change are furnished by the continual development of the emanations of thorium and radium and the gradual decay of the activity possessed by these emanations.

Two questions of the greatest importance at once suggest themselves in the consideration of radioactive substances. First of all, if the rays consist of particles shot off from the substances it would seem as though a diminution in weight should result. It seems hardly probable that matter could be gathered in from the surroundings to supply this loss. There is in fact some experimental evidence that strong active preparations lose in weight by a measurable amount; but this evidence is not yet to be regarded as conclusive. Observations to test this point are difficult. The change to be expected is extremely minute, even with the most active substances, and might easily be masked by the results of chemical changes produced by the rays in the walls of the containing vessel. But although the question must be regarded as unsettled, I think that most students of the subject are convinced that a loss of weight actually occurs, even though it has not as yet been detected.

A question of even more fundamental importance, and one that is now attracting especial interest, is that of the source of the energy which the rays possess. It has recently been shown by the Curies that one gram of an active radium preparation develops each hour forty calories of energy. In other words, a gram of this preparation could melt its own weight of ice in two hours. Expressed in a different form, this would mean that this salt of radium develops, in the course of a month, as much energy as is liberated by the combustion of an equal mass of hydrogen. When hydrogen is burned its store of energy is exhausted; but radium can apparently continue to give out this energy month after month, with no diminution in intensity which has yet been detected. The numerical results obtained by the Curies may require correction in the light of more accurate measurements; but the difficulty will still remain. How is it possible for a radioactive substance to continue radiating energy for an indefinite period without appreciable loss?

Several explanations have been suggested.

It has been thought, for example, that radioactive substances may have the power of absorbing the energy of certain rays, hitherto undetected, which are all the while proceeding through space, coming perhaps from the sun. The radioactive substances might utilize the energy thus absorbed in the development of Becquerel rays, just as fluorescent substances utilize the energy absorbed from sunlight in producing luminescent phenomena. This view, I believe, is supported by the Curies. Sir Wm. Crookes has suggested that radioactive substances possess the power of utilizing the energy of surrounding bodies. Such an explanation might possibly contradict the second law of thermodynamics; yet, since the process is not a cyclic one, I do not believe that any contradiction would be found. An objection to this explanation has been raised, based on the fact that radioactivity continues when the substance is placed in a vacuum. Crookes replies, however, that the best vacuum ever obtained contains millions of molecules per cubic centimeter, so that enough are left to supply the energy needed. A test might be applied, as suggested by J. J. Thomson, by placing the active substance in an ice calorimeter entirely surrounded by ice. If the ice melts, as is probable, it would seem that the Crookes explanation could not hold.

Elster and Geitel suggested, a few years ago, that the energy might be derived from processes of molecular or atomic change which accompany the development of Becquerel rays. According to this view, an active substance is one which is slowly changing from an unstable condition into a more permanent form; the processes which go on during this change may bring about the development of Becquerel rays, while the energy developed is that liberated during the transition. The production of Th-X from Th is perhaps the first stage in such a change; the decay in the activity of the Th-X and the production of the emanation, perhaps form the second stage; while a third step in the progressive alteration of the original substance is shown by the development of excited activity from the emanation. The final products of this disintegration process are doubtless much simpler in their structure than the original substance, and are probably not radioactive. It has been suggested that helium, which has so far been obtained only from radioactive minerals, may be one of the final products of radioactive change.

Perhaps the most serious difficulty in accepting the explanation just mentioned arises from the large quantities of energy involved. It seems almost incredible that so much energy could be stored in a few milligrams of material. The changes assumed are, however, atomic changes. May it not be that such changes involve energy quantities of a higher order? As we proceed from the ordinary motions of mass mechanics toward motions of a finer grain the energy involved increases. A falling raindrop possesses energy due to its mass motion; the energy liberated when it freezes is much greater; and the energy involved in the formation of the drop from oxygen and hydrogen is greater still. May not the energy of atomic synthesis and disintegration be as much greater than that of ordinary chemical change as the latter is greater than the energy of physical change? The view advanced by Elster and Geitel appears to me to give the best explanation that has yet been offered. But this question of the energy of the rays, like many other questions that have been raised by the study of radioactivity, can by no means be looked upon as settled.

ERNEST MERRITT.

THE TWENTY-FIFTH ANNIVERSARY OF DOCTOR VICTOR C. VAUGHAN'S GRADUATION.

On the 18th of June there was presented to Doctor Victor C. Vaughan, in the presence of alumni, students, colleagues and friends, a volume of contributions to medical research, containing thirty-four papers, dedicated to him by colleagues and former students of the department of medicine and surgery, in honor of the twenty-fifth anniversary of his doctorate.

ADDRESS OF PRESIDENT JAMES B. ANGELL.

Ladies and Gentlemen: My duty is a very simple and a very pleasant one, as the official head of the university, to express the gratification which the authorities of the university, as well as alumni and undergraduates, feel on this interesting occasion. We have come to follow a very agreeable custom, which we may say we are indebted to our German friends for establishing, of recognizing the services of a friend who has been of great use to this institution; and I am very glad that in introducing this pleasant German custom we have here the countenance of our German friend, Dr. Kiefer, who has done so much for this movement. I should prefer that he would have discharged this pleasant duty, but it is proper, perhaps, that I should appear, if only for a moment, in these services.

I am one of the gentlemen here who are old enough to remember when Doctor Vaughan was very young. I can well remember when we had the great pleasure of importing him from the trans-Mississippi region and the pleasure with which we watched his brilliant progress as a student. The medical department of this university has undergone great changes since that time. The courses of instruction were much briefer then, the period allotted to the study of medicine was very much shorter than it is now, and I presume those young gentlemen on the upper seats will believe that it was much less rigorous than it is now. The instruction was very largely given by lectures, and perhaps some of these recent graduates will be surprised to learn that some of the gentlemen in the faculty at that time very strenuously urged that it was far more profitable for the students to hear the lectures the second time than it was to hear them the first time. I used to argue this question out at length with one of the professors, because as a layman it was very difficult for me to understand how hearing the whole course of lectures the second time helped matters, but I was assured that, pedagogically, it was right, that it took the first year to mellow the medical student's mind up to the point where in the second year he could understand what was meant by the lectures. As you look down upon some of these older graduates, who went through that process of training, you must not interpret too literally as correct that view of the case. I presume these gentlemen will deny that that was the pedagogical reason for that course of instruction.

As I have said, the medical work in those days was more largely given by lectures than at present. The laboratory courses have come into use since that time. It is due very largely, I may say, to the dean of the department, though doubtless by the aid of many of his associates, that so great emphasis is now placed upon this new, and more profitable, mode of scientific instruction. Of the important part that he has played during these twenty-five years, I need myself hardly speak in detail; I can assure you, however, that it was with great pleasure that we who had witnessed his career as a student saw him very early fulfilling the promise which he had given as a student, in the brilliant

scientific discoveries which he has made, and which are of great importance in the hygienic history of his time. The promise that he then gave has been more than redeemed up to the present time, so that not only is his name well known and the name of the medical department of the university through him well known in this country, but also in all European countries.

I am sure there is no one here and no one ever connected with the university who does not feel grateful to him for the services he has rendered. Still more are we glad, notwithstanding his twenty-five years of service, to look into his face and see that he is still a young man and doubtless has a long career yet before him, and we shall be very glad to come here—some of you will have a better chance than I—twenty-five years hence to have another and more imposing celebration.

I am sure you all rejoice with us on this occasion, and I shall not detain you from the pleasure of enjoying the services which have been more especially appointed. I have risen merely to speak an official word, and also to have the pleasure of speaking a personal word of congratulation to one whom I delight to count as one of my most cherished friends.

Professor Albert B. Prescott, of the University of Michigan, made the presentation in behalf of the contributors.

ADDRESS OF PROFESSOR ALBERT B. PRESCOTT.

Fellow Alumni and Friends: I am honored surely in being asked to say something in this presentation of a gift to-day. It is a privilege as well as an honor to speak on the part of such men as those who are making this gift, men who are the most cherished and most influential of the medical alumni of this university.

For gifts there are returning times and seasons. For a gift there is now and then a period standing almost alone by itself. Of gifts there are various kinds and various meanings. Whatever a gift may be, it means more than it is. It is a mode of speech, a form of expression, a record of events. In the making of this gift a memorial volume has been wrought out piece by piece in the unwearied toil of strenuous life. For the making of this gift we have a quarter of a century, a period in the lifetime of an alumnus, an era in the history of this university, a memorable period in the advancement of a great scientific profession. The occasion is one that touches all our hearts.

This Festschrift is a symposium of scientific learning, a production of lasting import, an essential record of the advancement of science and of the profession of medicine. It consists of thirty-four separate investigations, each one conceived in faith and wrought in patience, each one the chosen product of its author's personal power. In such a piece of research work as is undertaken in the making of any one of these papers we can but imagine how advances are gained step by step, finding out what is right by proving what is wrong, reaching forward in this direction and then in that, assured that every result of truth adds something, may add much, to the sum of the knowledge and power and good of mankind.

If I were competent to speak of these records of researches in the domain of medical knowledge, I should not have time now even to enumerate them, but I recognize that they are from men who have become authorities in the world, by their several investigations and through their experience in scientific pursuits. As I look over the titles of these papers I see that they form a symposium of research, embracing certain fundamental principles, and presenting a series of discoveries, which unite together naturally

and inevitably to constitute a tribute of honor to the one man unto whom this gift is now being made. The book belongs to him, by virtue of its history and by virtue of its subject matter. We are but rendering what is due, and so this gift is made to you, Doctor Victor C. Vaughan, made to you as an acknowledgment of the services you have rendered to the world of science and this university, to the cause of medical education, to advances in scientific work wherever undertaken.

We have great pleasure in recalling, as President Angell has so feelingly done, the last quarter century of progress in this university. It is in fidelity to the spirit of advancement, and to service of the truth, that this volume is presented. It is in the conviction that scientific labor is at the heart of education and educational means and methods, that this expression is made. It is to you, Victor C. Vaughan, who twenty-five years ago received the degree of doctor of medicine from this university, previously having received two degrees in science, upon examination here; our friend known and honored in the country and in the world, major and surgeon of the United States Volunteers, a trusted counsellor, preeminently a leader in the work in which you are engaged, in the name of the working contributors to this volume, in the name of the alumni of the department of medicine and surgery, in the name of all the alumni of the university, we take great pleasure in placing this volume in your hands.

ADDRESS OF PROFESSOR VICTOR C. VAUGHAN.

On accepting the volume, Professor Vaughan spoke as follows:

Mr. President, Gentlemen of the Board of Regents, Doctor Prescott, Members of my old class, Colleagues and Friends: This I do not deserve. The world has been more than kind to me; my friends have conferred upon me many honors, which might have been more worthily worn by others; but I have never received an honor which I appreciate more highly and in the receiving of which I feel more keenly my unworthiness than in this. The work that I have done for the university and for science is overestimated by those who have been kind enough to speak.

I owe much to the University of Michigan. Thirty years ago when I had secured the best education possible in my native state, and when I was looking about for an opportunity to pursue my studies farther, the state of Michigan offered me what I desired and at a cost within the limits of my scanty purse. Whatever I have done, and whatever I may do in the future, will hardly repay the University of Michigan for what it has done for me. This is my feeling towards the university. To those who make up the university, I owe much. To our worthy president, to whom I have always gone in times of discouragement for words of cheer, to whom I have always gone in times of indecision or doubt for wise and able counsel, I owe much. To the honorable members of the board of regents I owe much. A few years ago, when it became necessary, on account of death and resignation, to reorganize the medical department, the members of the board of regents enabled me to select the present most excellent medical faculty. To my colleagues in the university as a whole I owe much. It has been a pleasure to live among them; it has been an inspiration to work and be associated with them; and, so far as my immediate colleagues on the medical faculty are concerned, I am in the habit of saying, and with great truth, that of all of the research work that I have ever done, the grandest and best piece is that, by the authority of the board of regents, I have been able to

collect together a medical faculty every member of which is a master in his specialty.

It is easy enough to have a good medical school, and it is easy enough to be dean of such a school, if you have a good faculty and good students, and I owe much to the students in this department. I want to say that the spirit for good, honest work and the inclination to be gentlemanly and honorable in everything have always prevailed among the student body in this university. It is an honor to me that I have been associated as teacher with some of the greatest scientific men in this country; however, these men do not owe their attainments to any instruction that they have received from me. They would have been great and probably greater still had their instruction been received from others.

I want especially to express my personal gratitude to him from whose hands I have received this volume. When I came a student to the University of Michigan, Doctor Prescott was then, and he still is, the Nestor of scientific research in this university. From him more than from any other man have I received the inspiration for scientific work which has led me to accomplish whatever I have done. I well remember one of the first problems at which he placed me. It was a new test or a newly reported test for arsenic, reported by one of the most distinguished of chemists, and the doctor asked me to determine its delicacy. I reported from day to day and week to week as to the delicacy of the test, until I was getting it down to high dilutions. One day when I made such a report the good doctor raised his eyebrows and said that possibly I might make that test without any arsenic present, and I made it and found the result equally positive.

President Angell has explained how it is that my classmates who occupy the second and third rows of seats before me, the class of 1878, got through the university. It was necessary, in order to get us through, that the lectures be repeated to us for two successive years and in this way we were finally nourished sufficiently to become doctors and be turned out on the world.

Now, my friends, in accepting this volume I shall not regard it as a trophy of any achievement. I shall regard it as a tribute of love and respect, which I shall prize more highly than anything else, from my colleagues, my students and my friends. In its pages I expect to find inspiration for farther work; in its pages I expect to find comfort in my hours of rest and when I am through with it I shall bequeath it to my children as my most valuable earthly possession. I take it, that this volume is presented to me as a result of the spirit of scientific research of those who have made these contributions, and I wish to say to the honorable board of regents that I hope that you will grant me the privilege never denied an old servant, to offer one word of advice and to say that if you wish to maintain the glory, honor and reputation of this university, you will encourage the young man who is able to do research work. It was not until scientific research came with experimental investigation, that the world began to grow and develop until within the last century its progress has been greater than in all the preceding centuries. It is scientific research that has made the German universities the very center not only of science, but of letters as well. I read only a few days ago a very interesting book by a graduate of Oxford, entitled 'Oxford at the Cross-Road,' and this man inquires whether Oxford and Cambridge are to continue as literary boarding houses, or whether they are to join the great universities of other

lands in working out the problems of the twentieth century. Scientific research has not always found the most congenial atmosphere in American universities. It has not been as thoroughly appreciated as it might be and as it should be, and the American university of to-day, like Oxford and Cambridge, stands at the cross-roads. Shall it be an enlarged and amplified high school, or shall it become a center for the evolution of knowledge and discovery. Has not the state the right to ask of its university the very best knowledge possible upon every subject in which the welfare of the people may be involved?

My friends, my heart, always larger than my head, overflows with the emotions which my poor tongue can not adequately express. I desire to thank all of you for this highly appreciated, but, I fear, poorly deserved, tribute.

SCIENTIFIC BOOKS.

A Text Book of Plant Physiology. By George James Peirce, Ph.D., Associate Professor of Plant Physiology, Leland Stanford Junior University. New York, Henry Holt and Company. 1903. 8vo. Pp. vi + 292.

The author of this work in his preface, which bears date of December, 1902, says that the book is the outcome of his own work in Stanford University, and that after the material had been worked over for some time in lectures it finally took form in the present volume. His intention is 'to present the main facts of plant physiology and the saner hypotheses regarding them, striving to express safe views rather than to echo the most recent, attempting here and there to suggest definite problems for investigation and everywhere trying to avoid giving the impression that the science or any part of it has reached ultimate knowledge and final conclusions.' This intent on the part of the author has been well carried out, and we may congratulate him upon the book which he has added to American botanical literature. He has made no attempt at giving directions for experiments, 'believing that a laboratory manual and a text-book must meet such different needs that the style of the one is impossible for the other.' However, the author insists that actual laboratory work must be carried on under the guidance of a teacher in the study of the subject.

Dr. Peirce gives his ideas as to the aim of physiology in the following words, which we may well quote:

"According to Pfeffer, 'the aim of physiology is to study the nature of all vital phenomena in such a manner that, by referring them to their immediate causes, and subsequently tracing them to their ultimate origin, we may arrive at a complete knowledge of their importance in the life of the organism.' Physiology is a study not merely of structure, though to its successful pursuit a knowledge of structure is indispensable; nor of organized bodies, though a knowledge of the laws which govern their organization (structure and form) is important. It is the study of the living organism."

On a later page he says: 'The physiologist is now striving not only to know the functions which are the manifestations of the life possessed by complicated living structures or organisms, but also to determine the causes, both of structure and of functions.'

These quotations will sufficiently indicate the spirit in which the book is written.

In the introductory chapter there is an instructive summary under the heading 'The Conditions Essential to Life' as follows:

"1. Proper Food—(*a*) the source of the materials of which the body is built, and (*b*) of the energy by which the body is built and operated.

"2. Water—(*a*) the vehicle of the food-materials and of the foods absorbed into the body and transferred from part to part, and also (*b*) an indispensable component of actively living protoplasm.

"3. Proper Temperature—which makes possible the vital, *i. e.*, the chemical and physical, changes which must go on within the body, and in all of its parts, lest inaction and death ensue.

"4. Proper Illumination—which furnishes the organism with the forms of energy—physical and chemical—thermal, luminous and actinic—of which it is directly or indirectly in need.

"5. Proper Freedom—freedom from mechanical and other disturbances which would interfere with its supply of food, water, warmth and light, and prevent it from carrying on its natural functions."

And again, under the heading 'The Living Matter and the Actively Living Structure,' the author says:

"As Hertwig has so strongly emphasized, the living and active protoplasm is to be regarded not as a chemical compound or an association of chemical compounds, but rather as an orderly arrangement of these into a definite structure, of which water is an indispensable constituent. Some of the water contained within the cell should be considered to be as much a constructive constituent of the living protoplast as the water is of the crystal of copper sulphate. As, without a certain amount of water, one can never have crystals, no matter how much copper sulphate may be present, so also, without the necessary amount of water we can never have active protoplasm. When the water of constitution is withdrawn, all the activities of the cell cease with the demolition of its structure."

In the carrying out of the author's plan he devotes one chapter to nutrition, another to absorption and movement of water, still another to growth, one to irritability and one to reproduction. In the chapter on the absorption and movement of water the author's treatment of transpiration is interesting. Thus, on page 136, we find the following:

"From all their surfaces exposed to the air, plants give off water-vapor. This is a physical necessity, for water-vapor will be given off from any mass, lifeless or living, which contains water, whenever the surrounding air is not saturated with moisture, or when the mass has a temperature higher than that of the air, or when the mass, in relatively dry air, is not enclosed in a waterproof covering. Other things being equal, the amount of water-vapor given off will be greater the greater the exposed surface in proportion to the mass. With like conditions of humidity, temperature, surface-composition and surface-area, equal masses of different composition, will dry, *i. e.*, lose water by evaporation, at different rates, a gelatinous or slimy mass more slowly than a woody one, for example. The living plant differs from a dead one of exactly the same dimensions in being able to control four of these five factors, and to that degree it is able to control the rate and the amount of evaporation. Because evaporation from the body of the living plant is controllable within certain limits by the plant itself, and to this extent is a physiological process, it has been given the separate name of transpiration."

After a little further discussion he says: 'Transpiration is, therefore, a physical process controlled but not carried on by the living plant. According to circumstances it may be more or less rapid than simple evaporation.' This view of the nature of transpiration is one which the present reviewer has held for many years, contrary to the views of many of the older physiologists, and it is gratifying to find that Dr. Peirce holds this physical view of the transpiration process.

In passing we notice with interest what the author has to say with reference to ecology, to which he refers very briefly on pages 252–253. Of it he says: 'Meantime it is more or less the fashion under the name of ecology to view things in the large way, and by feeling rather than by the application of exact physiological methods, to reach conclusions regarding the effects of environment and of association.' We gather from this that the author has little use for the looser ecological methods, and in this again the present reviewer must heartily agree with him.

The volume is full of original suggestions, and differs quite markedly from the old-time works devoted to plant physiology. We congratulate the author upon the success which we are sure must attend the publication of this book. CHARLES E. BESSEY.

THE UNIVERSITY OF NEBRASKA.

Caterpillars and their Moths. By IDA MITCHELL ELIOT and CAROLINE GRAY SOULE. New York, The Century Company.

In this handsome book of more than three hundred pages we have a very valuable contribution to the literature of popular entomology. The authors have mapped out for themselves a special field and have occupied it to excellent advantage. The caterpillars chosen for treatment are those of the larger moths, especially the more common ones, no

attempt being made to discuss the vast array of species in the Micro-lepidoptera.

The book is divided into two parts, the first fifty-six pages being devoted to the six chapters of Part I. In these chapters general directions for collecting, studying and rearing caterpillars are given—directions of great value to the beginner and of decided suggestiveness to the experienced entomologist. The remaining eleven chapters are devoted to the biographies of many species of Sphingidæ, Arctiidæ, Saturniidæ, Ceratocampidæ, Limacodidæ, Notodontidæ and Noctuidæ. These life histories are written in simple, lucid English, each insect being described in its progress from the egg to the adult in a way that any one can understand. The usefulness of the book is greatly increased by the admirable illustrations from photographs of living caterpillars and spread moths by Miss Edith Eliot. These are certainly among the best photographs of living insects that have been published.

The authors and the illustrator are to be congratulated on having prepared a book which will be of use not only to entomologists, but also to great numbers of teachers and pupils interested in nature study in the schools.

Clarence M. Weed.

SCIENTIFIC JOURNALS AND ARTICLES.

The June number (volume 9, number 9) of the *Bulletin of the American Mathematical Society* contains the following articles: 'Singular Points of Functions which Satisfy Partial Differential Equations of the Elliptic Type,' by M. Bôcher; 'Errata in Gauss's Tafel der Anzahl der Classen binärer quadratischer Formen,' by A. M. Nash (communicated by E. B. Elliott); 'The Logarithm as a Direct Function,' by E. McClintock; review of Klein-Fricke's 'Automorphic Functions,' by J. I. Hutchinson; review of Loria's 'Special Plane Curves,' by E. B. Wilson; 'Shorter Notices'; 'Notes'; 'New Publications.' The July number of the *Bulletin* contains: Reports of the April meeting and sectional meetings of the society; 'A Fundamental Theorem with Respect to Transitive Substitution Groups,' by G. A. Miller; 'The Characterization of Collineations,' by E. Kasner; review of Goursat's 'Cour d'Analyse,' by W. F. Osgood; 'Shorter Notices'; 'Notes,' and 'New Publications'; 'Twelfth Annual List of Published Papers' and index of volume 9.

The July number (volume 4, number 3) of the *Transactions of the American Mathematical Society* contains: 'On the Point-Line as Element of Space: A Study of the Corresponding Bilinear Connex,' by E. Kasner; 'On the Formation of the Derivatives of the Lunar Coordinates with Respect to the Elements,' by E. W. Brown; 'On Reducible Groups,' by S. Epsteen; 'Theory of Linear Associative Algebra,' by J. B. Shaw; 'Projective Coordinates,' by F. Morley; 'On an Extension of the 1894 Memoir of Stieltjes,' by E. B. Van Vleck; 'On the Variation of the Arbitrary and Given Constants in Dynamical Equations,' by E. W. Brown; 'The Primitive Groups of Class $2p$ which Contain a Substitution of Order p and degree $2p$,' by W. A. Manning; 'Complete Sets of Postulates for the Theory of Real Quantities,' by E. V. Huntington.

The University of Chicago will begin the publication on January 1 of a journal of infectious diseases, edited by Professors Ludwig Hektoen and E. O. Jordan. It is said that the journal will be endowed with $125,000 by Mr. and Mrs. Arnold F. McCormick.

SOCIETIES AND ACADEMIES.

THE UNIVERSITY OF CHICAGO MEDICAL CLUB.

The University of Chicago Medical Club, organized October, 1901, began its second season with a special meeting on December 1, 1902, at which Professor G. N. Stewart, who has succeeded Professor Loeb in the chair of physiology at the university, presented an interesting paper on 'Problems and Methods of Modern Physiology.'

On January 19, 1903, the club held its first regular meeting for the season, electing as officers for the year, Lewellys F. Barker, president, and Frank R. Lillie, secretary.

Meetings of the club were held through the winter and spring, as usual, once a fortnight,

and the following papers were presented in the order given:

DR. WILLISTON: 'The Fossil Man of Lansing, Kansas.'

DR. LUDWIG HEKTOEN: 'The Memorial Institute for Infectious Diseases: Its Purposes and Plans.'

DR. SHINKISHI HATAI: 'The Development of the Ventral Nerve Roots in the White Rat.'

DR. C. B. DAVENPORT: 'Recent European Work on Experimental Evolution.'

DR. P. BASSOE: 'A Case of Gigantism and *Leontiasis Ossea*' (illustrated).

DR. L. HEKTOEN: 'A Case of So-called Congenital Rickets' with lantern slides.

DR. E. O. JORDAN: 'The Recent Epidemic of Typhoid Fever in Ithaca, N. Y.'

DR. L. F. BARKER: 'The Morbid Anatomy of Two Cases of Hereditary Ataxia' (family described by Dr. Sanger Brown).

DR. H. G. WELLS: 'Fat Necrosis from the Standpoint of Reversible Enzyme Action.'

DR. A. P. MATHEWS: 'On the Nature of the Action of Salts on Protoplasm.'

DR. E. P. LYON: 'Experiments in Artificial Parthenogenesis.'

DR. CHAS. INGBERT: 'An Enumeration of the Medullated Nerve Fibers in the Dorsal Roots of Spinal Nerves of Man.'

DR. S. A. MATHEWS: 'The Diuretic Effect of Combined Salt Solutions.'

THE June number of the *Biological Bulletin* contains the following articles:

AXEL LEONARD MELANDER and CHARLES THOMAS BRUES: 'Guests and Parasites of the Burrowing Bee *Halictus*.'

J. B. JOHNSTON: 'The Origin of the Heart Endothelium in Amphibia.'

J. W. SCOTT: 'Periods of Susceptibility in the Differentiation of Unfertilized Eggs of Amphitrite.'

ARTHUR W. GREELEY: 'Further Studies on the Effect of Variations in the Temperature on Animal Tissues.'

BENNETT M. ALLEN: 'The Embryonic Development of the Ovary and Testis of the Mammalia' (preliminary account).

DISCUSSION AND CORRESPONDENCE.

ANTARCTICA.

TO THE EDITOR OF SCIENCE: In the *Geographical Journal of London* for May, 1903, there is a four-and-a-half-page review by Dr. Mill of my monograph 'Antarctica.' May I crave space in SCIENCE to bring before American scientists some of the points touched on?

Dr. Mill says: 'Mr. Balch surely does not need to be assured that no British geographer would dream of withholding credit from any explorer on the ground of his nationality, least of all if that nationality were American.' Let me answer this by some instances.

During the last six decades certain European geographers have made repeated attempts to decry Wilkes and his officers. As late as 1901, Lieutenant Colbeck, of the Royal Navy, now commanding the *Morning*, published in Mr. Borchgrevink's book, 'First on the Antarctic Continent,' a chart on which the southward track of the *Southern Cross* is marked as between 161° and 162° east longitude down to 66° south latitude, a spot at least three degrees distant from the most easterly point of Wilkes Land. The *Southern Cross* then sailed eastward and never approached Wilkes Land proper at all. Nevertheless Lieutenant Colbeck called his chart "Track of Sy. 'Southern Cross' over Wilkes Land."

Sir Clements R. Markham has made, during the last twenty years, many a disparaging statement about Wilkes and his men. Finally, in his article in the *Geographical Journal* for November, 1899, he says: 'The Victoria Quadrant first presents, for examination, the lands sighted by Balleny and Dumont d'Urville from 118° E. to the Balleny Islands in 162° E., namely, Adelie and Sabrina lands.' ***Wilkes is not mentioned.*** In other words, in this case the president of the Royal Geographical Society ignores absolutely American discoveries and American explorers.

Dr. Mill himself, it seems to me, is not quite fair to Fanning, upon whose veracity he casts reflections, not only in his present review, but also in the February number of the *Geographical Journal*. There is no reason whatever to impugn the veracity of Fanning, who was an American, as was Morrell, whom Dr. Mill also attacks, and it is worth while calling attention to the fact that Dr. Mill does not attack a single English explorer.

Dr. Mill finds fault with me because I

think Cook's voyage of less importance in antarctic geography than Wilkes' voyage. He says: "If such extraordinary reasoning were to be allowed, one might say far more justly of the first transatlantic voyage: 'North America was not discovered, a fact which would seem to rank the voyage of Columbus as of much less importance than the voyage of Cabot.'" But if Dr. Mill had compared the voyage of Columbus with the voyages of Columbus' predecessors, his simile would have been exact. A number of men sailed westward before Columbus, but their efforts produced no tangible result beyond showing that the ocean was a big space of water. But Columbus brought out the fact that there were great lands in the west, and for this he justly gets deserved credit. In the same way Cook only found ocean and ice round the South Pole, while Wilkes first discovered the existence of an Antarctic continent, and he, therefore, like Columbus, is entitled to the credit of the discovery.

Dr. Mill states that I have 'done a patriotic service, and also a service to science, in setting out the real achievements of Charles Wilkes,' and for this I beg to thank him. But he says I claim for Wilkes 'first discovery.' I have never claimed that Wilkes was the first to sight land in the Antarctic. On the contrary, I think it may have been Don Gabriel de Castiglio in 1603, or perhaps some entirely forgotten mariner whose possible discovery of West Antarctica before 1569 may have been the origin of the 'Golfo de S. Sebastiano' on the charts of Mercator and Ortelius. What I claim for Wilkes is that he was the first to discover land masses which were probably continental in their dimensions, and the first to announce to the world the existence of the probable South Polar continent. And every Antarctic discovery since the time of the American Exploring Expedition goes to show that Wilkes was correct.

Dr. Mill says that I am 'unjust to the memory of Sir James Clark Ross.' He does not specify how, but he apologizes for Ross as follows: 'We feel sure that Ross was not aware of Wilkes' orders dated 1838 at the time he wrote of the American and French expeditions.' Yet Ross had read Wilkes' 'Narrative,' for he quotes it repeatedly. Of the long and serious investigation I made of Sir J. C. Ross' charges against Wilkes—in which I stated that Ross paid no attention to the statements nor to the charts published by Wilkes, but quietly started a grievous error, and also that none of Wilkes' discoveries were disproved by Ross for the simple reason that Ross never was within sighting distance of any part of Wilkes Land—Dr. Mill does not say a word, and by his silence, therefore, he assents to my conclusions.

Edwin Swift Balch.

THE SPECIFIC HEAT OF MERCURY.

To the Editor of Science: May I direct attention to a corollary to the recently published work of Messrs. Barnes and Cook on the specific heat of mercury?* In these experiments a slender thread of mercury was heated by passing a current through it, and the results agree fairly well with other results obtained by previous experimenters who heated mercury in the ordinary way. The agreement might be still closer if the other results were as accurate as those of Messrs. Barnes and Cook. Petterson and Hedelius (quoted in the article referred to) failed to work accurately enough to detect the decrease of the specific heat with rise of temperature, and Regnault even thought the change to be in the opposite direction. As it is, the results agree well enough to show that, to about one part in 300, *the specific heat is not altered by the passage of a current.*

This fact, I think, can hardly be self-evident, and is worth an experimental proof. Specific heat is known to vary with temperature, *i. e.*, rapidity of agitation of the molecules, and experiments along this line may give us a clue to the nature of conduction, whether this takes place entirely through the intermeshed ether, or partly by a motion (twisting or otherwise) of the particles.

That the same is true for water as for mercury has been shown by the experiments

* *Physical Review*, February, 1903.

of Callendar with the same apparatus, described in the British Association 'Report' of the Toronto meeting, 1897. I have thought it worth while to test the same for solids. Carbon was the substance chosen, as being a conductor and as having the greatest known variability of specific heat with temperature and, therefore (presumably), with other disturbing factors. The method employed was to heat a fine carbon rod by a heavy current, and watch its expansion by means of an optical lever.

If a vessel containing a given quantity of water have its capacity suddenly altered by a bulging or a constriction of its sides, the result will be a change of level of the water. And if the specific heat of the carbon rod be suddenly altered when the current is started or stopped there should be observed a change of temperature which I hoped to detect by an abrupt alteration in the length of the rod. The results were entirely negative. The rod used was of French make, a Carré electric light carbon, 51 cm. long and 0.15 cm. diameter, wrapped in tissue paper and enclosed in a glass tube. Its resistance (cold), according to the nature of the contact made, was from about eleven ohms upwards. The rod was mounted vertically, its lower end resting in a mercury cup, and its upper end tilting a small lever on a knife-edge bearing. On this lever was mounted a galvanometer mirror. The current was taken from the upper end of the rod by a wire wrapped tightly around it. The tilting of the mirror was read by means of a telescope and a vertical scale placed two and one half meters away. The current used was three amperes. When the current was started or stopped a perfectly steady motion of the scale was observed. A jolt of 0.05 cm. in the field of the telescope could have been detected.

As about 6 cm. of the scale passed the cross wires before the still damp mucilage holding the tissue paper around the carbon began to steam, it will be seen that a jolt of 0.05 cm. would have meant a change in temperature of about two thirds of a degree, taking the initial temperature of the carbon as 20°, or 293° absolute. And a difference of level of two thirds of a degree in 293° would have meant an alteration in the heat capacity of about one part in 450.

PAUL R. HEYL.
THE RANDAL MORGAN PHYSICAL LABORATORY,
UNIVERSITY OF PENNSYLVANIA.

THE PROPOSED BIOLOGICAL LABORATORY, AT THE TORTUGAS.

TO THE EDITOR OF SCIENCE: In SCIENCE, June 12, 1903, is a letter by Professor C. B. Davenport upon the proposed biological station at the Tortugas. There are two sentences in it which I feel it necessary to comment upon. The first is: 'On the Pacific coast we have the Hopkins laboratory and that of the University of California.' The second is: 'While we are planning a chain of marine stations certainly * * * Puget Sound should be considered.' No doubt Dr. Davenport, who is quite familiar with the fact that the Minnesota Seaside Station at Port Renfrew, British Columbia, is just entering upon the third year of not altogether unsuccessful effort, means by 'we' the biologists of the United States. Under this construction it is altogether proper for him to omit the Minnesota Seaside Station from his calculations. In view of the fact, however, that this station, although upon Canadian soil, from which a number of memoirs and one volume of the yearbook, *Postelsia,* have already been published, is managed in connection with one of the American universities and has drawn its clientele principally from the western United States, it seems proper that it should be included as one of the Pacific coast stations of America. Its position on the Straits of Fuca was selected with great care so that it might be accessible as a center for the study of the fauna and flora not only of the sound but also of the open sea.

The Minnesota Seaside Station has not passed through the stage of an extended discussion in the columns of SCIENCE, nor has it intimated its pressing wants to Mr. Carnegie or any other millionaire. It has risen quite peacefully and modestly upon a cooperative basis which is none the less favorable for respectable work. Every year has seen considerable improvement both in its buildings and

equipment. It may or may not have the qualities of permanence. In any event, while it is upon its present basis, it is freely open to such students and investigators as might wish to work in its vicinity.

CONWAY MACMILLAN.

To THE EDITOR OF SCIENCE: I have been asked by Dr. A. G. Meyer to express an opinion regarding the establishment of a marine biological laboratory in the tropical Atlantic. As I have never been south of Bermuda, in these waters, I do not know that my ideas on the subject will be of much value. I see by the letters already published that the Tortugas are very generally favored. While for a botanist who is a student of marine algæ only, such a location might be an excellent one, it would hardly be suitable for one who wanted to study any other aspect of botany, for if I am not mistaken the land flora there is exceedingly scanty. A laboratory to be much sought after by botanists must also afford opportunities for the study of land plants, and where tropical vegetation is desired one must go further south than the Tortugas, and in a region where there is more moisture, to find much that is worth while.

HERBERT M. RICHARDS.

BARNARD COLLEGE, NEW YORK,
June 16, 1903.

THE MEDICAL RESEARCH LABORATORY OF COLORADO COLLEGE.

To THE EDITOR OF SCIENCE: It is proposed on the part of Colorado College to establish a pathological and research laboratory. For this purpose a room 23 by 14 feet has been set aside in the new Science Hall, now under erection. This room is to be equipped with chemical hood, water, gas and storage battery facilities. There are two windows in the room having a south exposure. In this laboratory it is planned that the following lines of work be undertaken: (1) Blood examinations, (2) sputum examinations, (3) urine examinations, (4) drinking-water examinations, (5) milk examinations, (6) pathological examinations, (7) stomach contents, (8) feces, (9) X-ray work as an aid to diagnosis, (10) papers and fabrics for mineral poisons.

In addition to these lines of general work special cases, requiring expert knowledge and care, will be undertaken. It is also planned that the director of the laboratory pursue lines of original research such as may be suggested by himself or by members of the committee under which the laboratory is to be conducted. It is hoped that this will grow to be the most important feature of the whole undertaking. Finally the laboratory will offer a limited amount of instruction in the pre-medical course of Colorado College. The amount and character of this instruction will be determined by consultation with the president of the college.

The salary of the director will be $1,500 for the first year. It is hoped that thereafter the income of the laboratory will prove sufficient to warrant an increase. It is the desire of the committee to receive applications for the position of director of the laboratory, the appointment being made for one year. The applicant should be a man of scientific spirit and one who is desirous of making his reputation along lines of medical research. It is not essential that he be a graduate of a medical college, but rather that he have had training and experience in some of the best laboratories of this country or Europe. He should not be a person expecting later to enter the practice of medicine.

Applications with full information and testimonials may be sent to

W. F. SLOCUM.

COLORADO COLLEGE,
COLORADO SPRINGS, COLO.

ABBREVIATIONS OF NEW MEXICO.

MAY I suggest that the name New Mexico should always be abbreviated (if at all) to New Mex. or N. M., never to N. Mex. or N. Mexico? The latter abbreviations have been used a great deal by naturalists, with the result of producing much confusion between New Mexico and North Mexico. Foreigners, especially, are almost sure to take N. Mexico for North Mexico; and I am afraid a good many people, not all foreigners, do not know that there is any difference! (I received the other day a letter from an important scientific

establishment in New York, with five cents in stamps on the envelope!) I am aware that in several of my own published papers the objectionable abbreviations occur, but these (and many other queer things) are due to editorial interference.

T. D. A. COCKERELL.

'TABLETTES ZOOLOGIQUES.'

TO THE EDITOR OF SCIENCE: Will you kindly give me space to inquire if any reader of SCIENCE knows of the existence in the United States of a copy of the 'Tablettes Zoologiques'? This journal was published at Poitier, France, by Aimé Schneider. The first volume appeared in 1885, and the third, which I think was the last, in 1892. I have as yet been unable to locate a copy in America, and any information will be very gratefully received.

HOWARD CRAWLEY.

WYNCOTE, PA.,
June 12, 1903.

SHORTER ARTICLES.

UNUSUAL ABUNDANCE OF A MYRIAPOD, PARAJULUS PENNSYLVANICUS (BRANDT).*

DURING the latter part of August and the first of September, 1902, the walks and drives along the university campus were overrun with a myriapod which proved to be *Parajulus pennsylvanicus* (Brandt). Bright, sunny days, which were likewise cool, were observed to bring a greater number of the species into evidence. Complaints were made by residents along the adjacent avenues of the numbers of these 'worms,' as they were called, which covered the sidewalks and terraces and even entered the residences. Often in passing along the paths running in the campus it was found to be difficult, if not impossible, to avoid crushing numbers at every step. They exhibited no general direction to their movements, and hence a migration from one portion of this locality to another definite locality seems not to be the case. Rather it seems that they were trying to find higher or perhaps dryer ground. When one was taken up in the fingers and then allowed to move in a direction opposite to its original direction, it showed no sign of any attempt at orientation.

A case similar to this one is found every year on Cedar Point, Sandusky, O., where *Fontaria indiani* Bollman, immediately prior to and during ovipositing, is found in great numbers along the lowlands on the Bay side. But in the case of the one mentioned above as occurring on the campus, of all the females examined, none contained eggs. Hence this is not a true parallelism.

Several cases of extensive migrations of myriapods are on record. In the *Zoologischer Anzeiger* for 1900, Verhoeff records a migration of such extent that railroad trains were stopped, owing to the numbers that were crushed under the wheels and thus caused them to slip. The species in this case was *Julus terrestris*. Verhoeff also calls attention to a description of an extensive migration of a species of *Brachyjulus*, given in the same journal by an Austrian named Paslavisky, who states that in 1879, in Austria, this species was excessively numerous in a certain district. Verhoeff regards the cause of such movements as due to over-population, and hence an attempt to obviate the results of the law of Malthus. That this is not the cause in all cases is attested by that of the species of *Fontaria* that I mentioned as occurring on Cedar Point, which is undoubtedly a purely sexual matter. A third record of such movements is given in Bollman's 'Myriapoda of North America,' in which, on page 75, he mentions the occurrence of *Fontaria virginiensis* (Drury) in Donaldson, Arkansas, in such numbers as to attract general attention. The adults were found to bear a ratio to the number of young that were observed with them of about one to three hundred. Apparently, this movement is due to a third reason —the migration of the adults with the young. Miss Mauck (*American Naturalist*, XXXV., 447) gives an account of a migration of *Fontaria virginiensis* (Drury) but no cause is assigned to the movement.

To conclude, every one of the cases of extensive migrations in myriapoda that have

* Read at Columbus meeting, Ohio Academy of Science, November, 1902.

been recorded seems to have a cause peculiar to itself. This may be either connected with mating or it may have nothing to do with it, as seems to be the case with the form described as occurring about the university campus. As a possible explanation of the movement in the present case, it may be offered that it is a preparation for winter. The adults live over the winter under logs, leaves, etc. Their eggs are laid in low, damp areas. Such localities are unfit for hibernation, and hence the migration to more dry and protected localities.

MAX MORSE.

DEPARTMENT OF ZOOLOGY,
OHIO STATE UNIVERSITY.

RECENT ZOOPALEONTOLOGY.

STEGOCERAS AND STEREOCEPHALUS.

This review of the above-named genera of dinosaurs, by the able paleontologist Franz Baron Nopcsa (Centralblatt für Mineralogie, etc., 1903, No. 8), is a highly important one and is, at the same time, suggestive of our limited knowledge of the Dinosauria generally and of the great results to be looked for from the study of this group of reptiles in the future. These animals were recently described by the writer from the Belly River formation of the Red Deer River region. One has a solid horn in the front part of the skull, the other a solidly plated head.

Nopcsa's interpretation of the *Stegoceras* skull elements is noteworthy and accentuates the necessity of having more material for study before definite or final determinations can be made. He comes to the conclusion that the *Stegoceras* specimens that were supposed to be from 'the median line of the head in advance of the nasals'* are to be interpreted rather as representing the frontal and nasal elements of the skull.

In support of this decision attention is called to the frontal of *Camptosaurus prestwichi*, as figured by Hulke in the *Quarterly Journal of the Geological Society* for 1880. In this figure the strong, general structural resemblance to the *Stegoceras* specimens, particularly noticeable on the under surface, is pointed out with emphasis. Reference is also made to a similarly shaped, but as yet undescribed, frontal of *Mochlodon*.

* Geological Survey of Canada. Contributions to Canadian Palæontology, Vol. III. (quarto), pt. II., p. 69, pl. xxi, figs. 1–5.

According to the above interpretation, *Stegoceras* brings to our notice an entirely new type—a unicorn dinosaur, of especial interest in that heretofore a form having an unpaired horn springing from the frontonasal region was unknown.

It is still considered problematical whether *Stegoceras* should be assigned to the Ceratopsidæ or to the Stegosauridæ.

Stereocephalus, the second genus, is referred by Nopcsa to the Acanthopholididæ, and is regarded as a new and important type capable of throwing additional light on the modification of the skull of the Ceratopsidæ.

It is hoped that further contributions to our knowledge of the Cretaceous dinosaurs may be forthcoming from the pen of this sympathetic writer and gifted observer.

OTTAWA, LAWRENCE M. LAMBE.
May 26, 1903.

SCIENTIFIC NOTES AND NEWS.

THE remaining separata of the late Professor Edward D. Cope have been arranged in sets and are ready for free distribution to students and institutions willing to pay express charges on them. Application should be made to Mrs. E. D. Cope, Haverford, Pa.

WESLEYAN UNIVERSITY has conferred its LL.D. on William D. Brewer, professor emeritus in the Sheffield Scientific School of Yale University.

THE ex-resident physicians and associate physicians of Johns Hopkins Hospital gave a dinner on May 15, at the Maryland Club, Baltimore, in honor of Dr. William Osler, at which he was presented with a copy of the 'Dictionary of National Biography.'

THE Zoological Society of London has confirmed the action of the council in granting a pension of £700 to Dr. P. L. Sclater, F.R.S., in consideration of his services to the society for forty-three years.

PRESIDENT W. G. TIGHT, of the University of New Mexico, is with the Annie S. Peck

expedition in South America to climb Mt. Sorata and to make geological observations.

DR. DOUGLAS H. CAMPBELL, professor of botany in Stanford University, is on a vacation trip to New Zealand and Australia.

MR. ALBERT P. MORSE, curator of the Zoological Museum of Wellesley College, is spending the summer studying the geographical distribution of locusts in the south.

DR. CLEVELAND ABBE, JR., has recently returned to Washington, after spending two years with Professors Julius Hann and Albert Penck in the study of the climatology and glacial phenomena of Europe. He has accepted temporarily a short engagement in the U. S. Weather Bureau, working on the climatology of Guam, for publication in a forthcoming report by Mr. A. E. Safford.

Nature, quoting from the *Victoria Naturalist*, reports the retirement of Sir James Hector, K.C.M.G., from the directorship of the Geological Survey of New Zealand and of the Colonial Observatory.

COMMANDER DON JULIAN IRIZAR, Naval Attaché to the Argentine Legation in London, has been appointed to command the vessel *Uruguay*, which will be sent by the Argentine Government in October to the Antarctic regions in search of Dr. Otto Nordenskjöld's South Polar expedition, which was joined at Buenos Ayres in 1901 by an officer of the Argentine Navy.

Nature states that Professor Steinmann, of Freiburg, and two of his fellow geologists of the same university, have arranged an expedition to the Central Andes of Bolivia. The party will start in August for Buenos Ayres, whence the route to be taken is *via* Jujuy, Tarija, Sucre, to Cochabamba. After a prolonged stay in the mountains the explorers will probably work their way to Antofagasta *via* La Paz.

DR. IRA REMSEN, president of the Johns Hopkins University, gave the commencement address at the Armour Institute of Technology.

WE learn from the *British Medical Journal* that at the meeting of the Zoological Society of London on June 16 Mr. F. E. Beddard, F.R.S., exhibited on behalf of the memorial committee a bust of the late president of the society, Sir William Henry Flower, K.C.B., who before he became director of the Natural History Museum was curator of the museum of the Royal College of Surgeons. The bust has been executed by Mr. Thomas Brock, R.A., and will be placed in the Natural History Museum.

A MEETING was held at London on June 29 to consider the erection of a memorial to Sir Henry Bessemer, to which we have already called attention. It is said that the king is interested in the plan and that Mr. Andrew Carnegie will make a substantial subscription. One of the addresses was made by Professor H. M. Howe, of Columbia University.

MR. GEORGE SHATTUCK MORRISON, one of the most eminent of civil engineers, died in New York on July 1, at the age of sixty years. He was born at New Bedford, Mass., and graduated from Harvard in 1863. Mr. Morrison was especially known for the large number of bridges he constructed, including some fifteen across the Mississippi and Missouri Rivers. He was a member of the Isthmian Canal Commission.

MISS LILLIE SULLIVAN, chief illustrator in entomology in the department of agriculture, died on June 26.

THE deaths are also announced of Carl Gussenbauer, professor of pathology and rector of the University of Vienna; of Dr. Josef de Smeth, formerly professor of psychiatry in the University of Brussels, at the age of seventy-seven years, and of Professor Luigi Cremona, director of the Engineering School of the University of Rome.

THE park commissioners of Chicago have approved the transfer of the Field Columbian Museum from Jackson Park to Grant Park, which is on the lake front in the center of the city. It is understood that Mr. Marshall Field has agreed to give $5,000,000 for the construction and endowment of the museum.

THERE will be a civil service examination on August 1, for the position of consulting

engineer in the U. S. Geological Survey at a salary of $300 a month. The results will depend on experience and previous work, it not being necessary for applicants to appear at any place for examination. There were no applications for this position when the examination was announced on July 1.

THE Department of Commerce and Labor was formally organized on July 1. In addition to the Bureaus of Corporations and Manufactures created by the new law, it embraces the Census Bureau, formerly under control of the Interior Department; the Lighthouse Establishment, Steamboat Inspection Service, Bureau of Navigation, United States Shipping Commissioners, National Bureau of Standards, Coast and Geodetic Survey, Bureau of Immigration and Bureau of Statistics from the Treasury Department, the Bureau of Labor, Fish Commission, and the Bureau of Foreign Commerce, the last being transferred from the State Department.

EFFORTS are being made towards the organization of a society for horticultural science, which would meet in connection with some kindred society, such as the American Association for the Advancement of Science or the American Pomological Society. If there is sufficient interest in the plan the first meeting will be held in conjunction with that of the American Pomological Society at Boston on September 10 to 12. Further information may be obtained from Mr. S. A. Beach, New York Agricultural Experimental Station, Station, Geneva, N. Y.

THE American Forestry Association will hold its summer meeting at Minneapolis on August 25 and 26.

THE Royal Institute of Public Health will hold a congress at University College, Liverpool, from July 15 to 21, under the presidency of the Earl of Derby.

THE International Congress of Applied Chemistry has adjourned to meet in Rome in 1906.

THE *National Geographic Magazine* states that at a conference of representatives from the several geographic societies in the United States, held Saturday, June 20, 1903, in the American Geographical Society Building, 15 West Eighty-first Street, New York city, to arrange for the meeting of the Eighth International Geographic Congress, to be held in this country in 1904, the organization of the committee of arrangements was perfected by the election of Professor W J McGee, of the National Geographic Society, Washington, D. C., chairman, and Dr. J. H. McCormick, secretary. It was formally voted to hold the congress in Washington in September, 1904, adjourning to St. Louis, Missouri, to meet in connection with the International Congress of Arts and Sciences. In addition to the formal sessions of the Congress in Washington, it is planned to hold informal sessions or social meetings in other cities. After the final session in St. Louis, a trip is planned to the City of Mexico, the Grand Canyon, Yosemite Valley, Yellowstone Park, and other points of interest to the members of the congress. The following subcommittees were appointed: *Program,* Mr. C. C. Adams, of the American Geographical Society; *Exhibits,* Mr. Henry G. Bryant, of the Geographical Society of Philadelphia; *Invitations,* Mr. A. L. Rotch, of the Appalachian Mountain Club; *Transportation,* Dr. G. B. Shattuck, of the Geographic Society of Baltimore; *Finance,* Messrs. C. J. Bell, David T. Day and John Joy Edson. The appointment of other committees was deferred till the next meeting of the committee of arrangements. A formal prospectus will be issued in a few days.

THE Australasian Association for the Advancement of Science will meet at Dunedin, New Zealand, in January next under the presidency of Professor T. W. E. David, of the University of Sydney, Captain F. W. Hutton, F.R.S., Canterbury Museum, Christchurch, being the retiring president. The sections and their presidents are: A—astronomy, mathematics, physics and mechanics, Professor W. H. Bragg; B—chemistry, Mr. J. Brownlie Henderson; C—geology and mineralogy, Mr. W. H. Twelvetrees; D—biology, Colonel W. V. Legge; E—geography, Pro-

fessor J. W. Gregory, F.R.S.; F—anthropology and philology, Mr. A. W. Howitt; G—(1) social and statistical science, president not yet appointed; G—(2) agriculture, Mr. J. D. Towar; H—architecture, engineering, and mining, Mr. H. Deane; I—sanitary science and hygiene, Dr. Frank Tidswell; J—mental science and education, Mr. John Shirley.

Nature states that in connection with the meeting of the International Meteorological Committee at Southport during the British Association week in September next, it is proposed to make arrangements for an exhibition of meteorological appliances and other objects of meteorological interest. Upon the initiative of the Meteorological Council, with the cooperation of the Royal Meteorological Society and the Scottish Meteorological Society, a committee has been formed to carry out this proposal. It is proposed to group the exhibits into four classes: (*A*) meteorological statistics; (*B*) weather telegraphy; (*C*) atmospheric physics, including (*a*) meteorological photography; (*b*) instruments and instrumental records; (*c*) high level stations, balloons and kites, observations and records; (*d*) experimental illustrations; (*D*) the relation of meteorology to other branches of physics.

THE Royal Statistical Society announces that the next competition for the Howard medal will close on June 30, 1904. In addition to the medal, a grant of £20 will be awarded to the writer who may be the successful competitor. The subject is 'The effect, as shown by statistics, of British statutory regulations, directed to the improvement of the hygienic conditions of industrial occupations.'

THE Department of Public Improvement of the Mexican government has under consideration the advisability of establishing commercial museums in connection with the more important consulates in foreign countries. Through the efforts of the Mexican consul at Liverpool, England, an exposition of the products of Mexico is about to be inaugurated at that place. The governors of the several states have been requested to forward samples of the principal productions of their respective sections. Precious woods, fibers, cereals, vanilla beans, coffee, sugar, etc., are to be sent at once to the consulate at Liverpool. The Mexican exposition at Milan, Italy, is in complete working order.

WE learn from *Nature* that for the first time for about forty years the Royal Society of Edinburgh, on the evening of June 6, held a conversazione. Lord and Lady Kelvin and Sir William Turner received the guests. There were many interesting exhibits from several departments of the Universities of Edinburgh, Glasgow, and St. Andrews, from the Geological Survey of Scotland, the Scottish Antarctic Expedition, etc. Professor McIntosh, of St. Andrews, sent a large collection of pearl shells and animals, living and dead, and great interest was taken in Professor Ewart's exhibition of hybrid ponies. Some of the lantern exhibits were particularly attractive, notably the projection on the screen of tanks of living worms, crustacea, etc., and a fine selection of slides made from Piazzi Smyth's 'cloud' negatives. Among the inventions and novelties exhibited, Dr. Halm's instruments for mechanically correcting stellar observations and for solving Kepler's problem in any given case, and Dr. Hugh Marshall's petrol incandescence lamp are worthy of mention.

DR. MORRIS, the Commissioner of the Imperial Department of Agriculture for the West Indies, who has been visiting British Guiana at Mr. Chamberlain's request, addressed a meeting of the members of the Royal Agricultural and Commercial Society of Georgetown on cotton cultivation and other minor industries. With regard to cotton, according to a report from Reuter's agents, he expressed the opinion that at first only light machinery should be introduced for its treatment. Addressing the Board of Agriculture, Dr. Morris expressed his admiration at the great amount of progress which had been made in the colony since he had visited it six years ago. There was evidence of quite a new feeling. Quite a new energy seemed to have taken hold of the leading planters and also the lead-

ing officials. He had not the slightest hesitation in saying that the board of agriculture was doing most excellent work. It was keeping in contact with all classes of the community; it was, fortunately, in sympathy with small cultivators as well as large cultivators. If the people interested themselves in the work of the board and benefited by its advice, he had no doubt that the colony would in a few years be in a very much better position than it was at present. With reference to the sugar-cane experiments, under the direction of Professor Harrison, the commissioner stated that the work carried on was not surpassed in any part of the world where the sugar-cane was cultivated.

UNIVERSITY AND EDUCATIONAL NEWS.

It is said that the trustees of the Rush Medical College, the medical department of the University of Chicago, have collected \$1,000,000 for the institution. The newspapers and medical journals state, we hope correctly, that this assures a gift of \$6,000,000 to the school by Mr. John D. Rockefeller.

Mr. H. O. Peabody, of Boston, inventor of the rifle that bears his name, has bequeathed the greater part of his estate, which is valued at about \$1,000,000, for the establishment of a school for girls, to be situated at Westwood, Mass.

The supreme court of Indiana has decided the Donaldson case in favor of the state. this gives the Indiana University about 200 acres of primitive forest land, abounding in sink holes, valleys and numerous dry and wet caves, including entrance to an underground stream which can be followed for more than a mile and which is the richest locality for blind fishes in North America.

Lord Iveagh has given £34,000 to Dublin University for the erection of laboratories for the physical and natural sciences, on condition that an endowment of £100,000 is provided within three years.

Plans are being urged in London for the establishment of a scientific and technological institute for advanced work. Subscriptions are being secured, and the London County Council has been asked for an annual grant of \$150,000.

Mrs. Stern and Mrs. Hardy, daughters of the late Sir George Jessel, formerly master of the rolls and vice-chancellor of the university of London, have offered to present to the university a sum of £2,000 for the establishment, in memory of their father, of a scholarship in law or higher mathematics, to be held at University College.

Appointments at Brown University have been made as follows: Arthur H. Blanchard, assistant professor of civil engineering; Dr. Leonard W. Williams, assistant professor of biology; Dr. Michael X. Sullivan, instructor in chemical physiology; J. Ansell Brooks, instructor in drawing.

Professor William Caldwell, of Northwestern University, has been appointed professor of philosophy at McGill University.

Dr. R. M. Pearce, of Philadelphia, has been appointed director of the Bender Hygienic Laboratory and adjunct professor of pathology and bacteriology in Albany Medical College.

Dr. Raymond H. Pond has been elected professor of botany and pharmacognosy and director of the microscopical laboratories at the Northwestern University.

Dr. John C. Hemmeter, Ph.D. (Johns Hopkins University, 1890), M.D. (University of Maryland, 1885), graduate of the Royal Gymnasium, Wiesbaden, has been elected to the professorship of physiology in the University of Maryland, vice Professor Francis T. Miles, resigned. A new laboratory for physiology and pathology will be erected during the summer for which the sum of \$75,000 has been appropriated. Professor Hemmeter has also been elected a regent of the University of Maryland.

Dr. A. F. Dickson, now of University College, Cardiff, has been elected professor of anatomy at Dublin University.

Dr. K. J. V. Orton has been appointed professor of chemistry at the North Wales University College at Bangor.